Analyzing the Absence of Renewable Portfolio Standards in Georgia

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24 February 2015

ABSTRACT

As the effects of climate change grow increasingly harmful and the dangers of a warming planet significantly impact both individuals and communities, the United States' is being called upon to reduce their overall carbon dioxide emissions. Electricity generating power plants, responsible for 40% of the nation's carbon dioxide output, have been challenged to implement cleaner practices (EPA, 2014). One response to this are Renewable Portfolio Standards (RPS), now widespread state policy tools. RPS are commitments placed upon energy providers to attain a pre-determined fraction of their electricity from renewable sources. Suppliers of technology for renewable sources however, have difficulty competing economically with utilities that employ conventional power, like coal and natural gas. Fossil fuel generators face lower collection costs than their renewable counterparts. The issue consequently becomes one of "fully-accounted" costs, recognizing both environmental and economic externalities. By obliging states' industries to obtain a specified fraction of their electricity from renewable resources, a market demand is simultaneously created. There is however, a significant absence of RPS throughout the Southeastern United States, made more intriguing by the region's seemingly substantial solar, wind, and biomass potential. Is this discrepancy the result of a lack of renewable resource capacity or a shortage of political will to enforce "left-wing" policies in a notoriously conservative region? Could the existing electrical system's deep investment into nuclear power undermine a motivation to pursue renewables? If RPS were to be adopted, would the efforts be significant in mitigating carbon dioxide and lessening the threats of climate change, all founded upon a more sustainable electrical system in the United States?

BTU: British Thermal Unit

EIA: Energy Information Administration

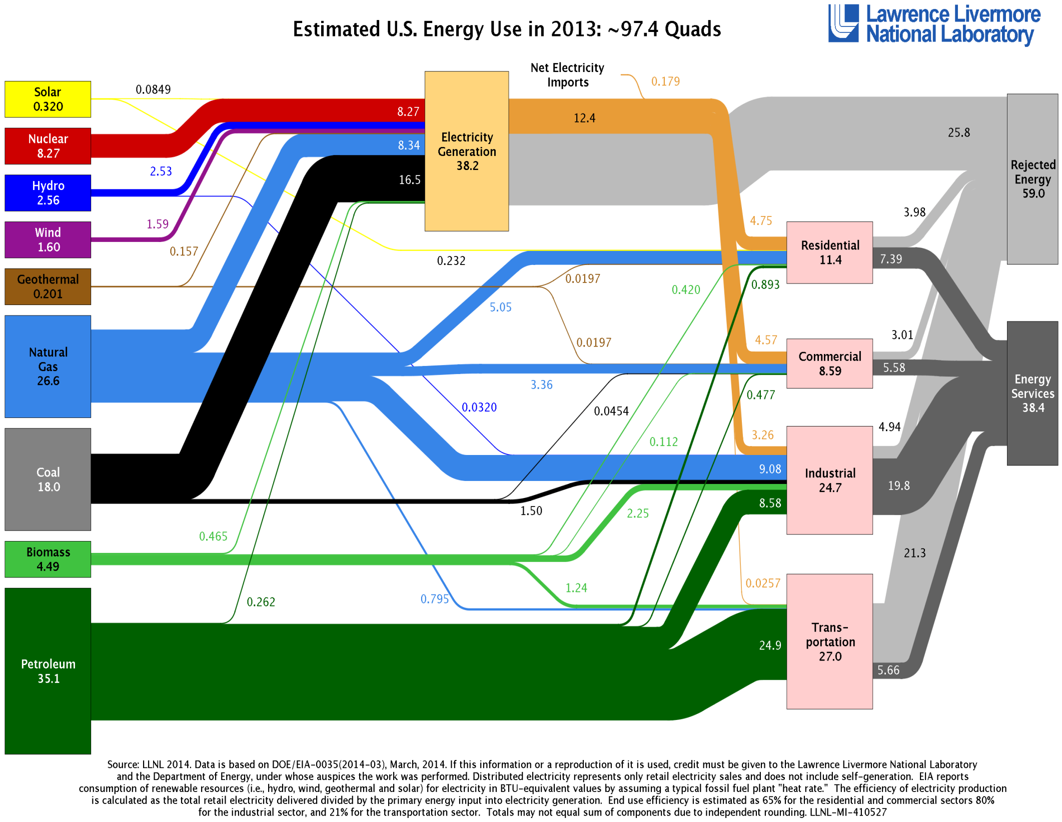
GHG: Greenhouse Gases

RPS: Renewable Portfolio Standard

INTRODUCTION

In 2013, the United State's total primary energy consumption was approximately 97 Quads (quadrillion BTUs), about 40% of which was expended generating electricity. From this sector, 43% came from the combustion of coal and 20% from the combustion of natural gas (*Figure 1*). Together, electrical energy generation from these fossil fuels accounted for roughly 40% of the nation's total carbon dioxide emissions (EIA Energy Annual Report, 2013). The heat-engines that turn these generators convert 32% of combustion energy into the mechanical work of electrical generation. In other words, about 67% of that combustion energy is lost as heat—an unavoidable thermodynamic transaction cost of converting heat to mechanical work in a cyclic heat engine. From the perspective of carbon dioxide emissions and climate change, about two thirds of the electric-utility carbon dioxide emissions are associated with waste heat. Consequently, the electric energy sector is a primary target for reducing dependence on the combustion of fossil fuels (coal and natural gas).

Figure 1- EIA Sankey Diagram of Energy Use by Sector



One means of reducing carbon dioxide emissions is to create electricity from “renewable” energy sources: some combination of sunlight, wind, biomass, falling water (hydroelectricity), and geothermal potential. Renewable energy sources have not been economically competitive with well-established coal and natural gas fired power plants, and as a result, electrical utilities have little incentive to adopt such practices. Consequently, advocates of expanded renewable energy production see government intervention, whether through financial incentives or regulations, as a means of cutting carbon dioxide discharge from the electrical sector.

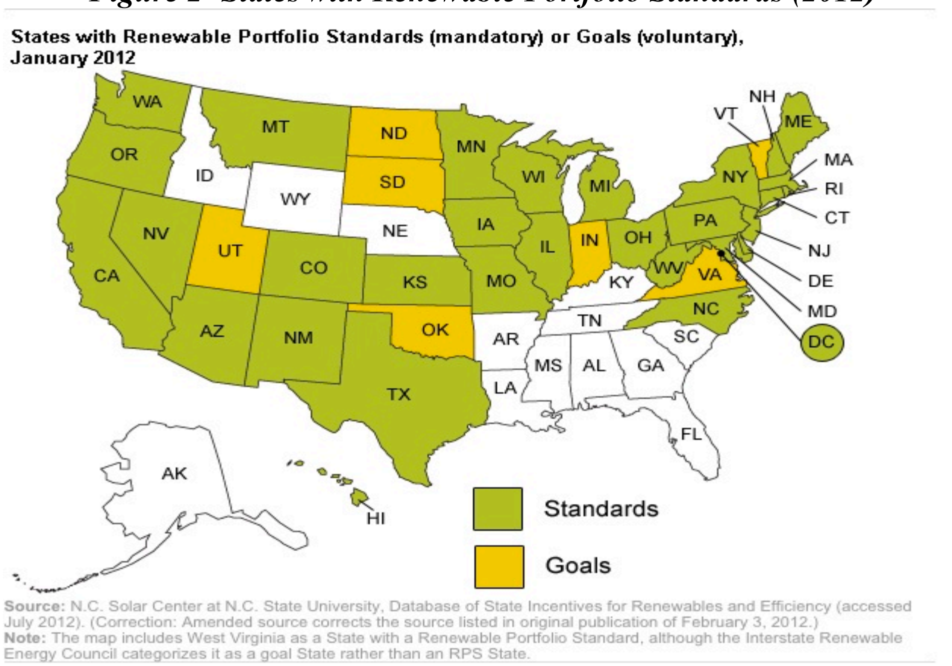
In the late 1990s, California introduced the concept of mandated Renewable Portfolio Standards (RPS) as state-level mechanisms that require electrical companies operating within the state to generate a specified percentage of electricity sales from renewable energy sources. An underlying assumption of renewable portfolio standards (RPS) is that utilities will find the means necessary to reduce the additional expenses of deriving a greater proportion of electricity from renewables. As a result, RPS would ultimately catalyze the competitiveness of renewable energies through this market-based, bottoms-up approach (Rabe, 2007). While a primary goal of RPS is mitigating carbon dioxide emissions, they have additional environmental and health benefits stemming from reduced air pollutants, mainly released by coal. Following California, RPS have emerged as exclusively state-level tools. This is due to a lack of authority within the Federal Energy Regulatory Commission (FERC), the agency with regulatory authority over the electrical utility industry, to enforce a national RPS mandate, as well as Congress's seeming unwillingness to enact legislation that would create a national RPS.

Since the appearance of California's initiative, thirty-seven states have established RPS, and currently these mandates are the most widespread state-level legislative approach to encourage renewable energy sources for electricity generation (Shrimali, 2012). Each state develops its own goals for carbon dioxide reduction, timeframe for implementation, and enforcement mechanisms. Each state also determines what mixture of renewable resources will be used (wind, solar, etc), depending on their corresponding resources available.

THESIS RESEARCH QUESTION

A curious feature of RPS initiatives is their absence in the Southeastern region of the United States, specifically Louisiana, Mississippi, Alabama, Georgia, South Carolina, and Florida (*Figure 2*). It is noteworthy because this area is commonly regarded as "sunny"—their latitude range (below 25 degrees) is slightly south of the solar-energy hot spots in the Southwestern United States—and presumably has abundant solar power potential. The Southeast has forestry and agriculture industries that could produce biofuels, and at least superficially there are no reasons to assume that the wind resources are not at a minimum as good as those of several of the 37 states with RPS. The question then is: Why have the Southeastern states not adopted RPS if abundant resource potential exists? The following thesis examines this question through four hypotheses that individually or in association could provide an answer.

Figure 2- States with Renewable Portfolio Standards (2012)



THE FRAMEWORK OF RPS

Before attempting to answer this question, it is necessary to understand that RPS are "local" constructions, and individual states can choose whether or not to institute mandates. There are no federal governance mechanisms for standardizing RPS among states, and consequently comparisons of RPS frameworks among states—essentially what works and what doesn't— are subject to consideration of local conditions. Some states that have adopted RPS may base their goals upon delivered electrical energy (expressed as megawatt hours), while others could base their goals on electrical generating power capacity (expressed as megawatts)—by either metric the target for the fraction of total electrical energy generated from renewables falls in the range 4-30%. The details depend on resource availability, electricity demand, and population distribution. Additionally, the goals reflect local secondary objectives. Some states may see opportunities for "new jobs" associated with renewable energy technologies (e.g. solar panels and wind turbines); others perceive opportunities to potentially tap into federal fiscal stimulus packages. Others may see disincentives because of the costs to taxpayers if utilities were subsidized to implement RPS goals, as well as the costs of electricity to end-users.

Ultimately, RPS are predominantly aimed at "large" central electric utilities that generate the majority, which quantitatively varies among states, of electrical energy. Each state's smaller municipal generators and cooperatives constitute "special cases", depending on the state's regulatory structure. In terms of large central utilities, however, there are conventionally three options for meeting RPS requirements. The first is by operating independent renewables-derived electrical generating facilities. The second is by purchasing Renewable Energy Certificates (RECs) from qualified "green" energy producers, who then allocate the right to the benefits achieved from their clean energy back to the buyer. The final method is the purchase of "bundled renewable electricity", meaning a group can buy energy directly from a solar, wind, biofuel/biomass, or geothermal facility (EIA, 2014).

RPS's emergence in California was initially a political experiment to reduce the environmental impacts of electricity generation while simultaneously creating a healthy market for renewable technologies. When considering the fact that 37 states have adopted RPS, it seems reasonable to conclude that these states have decided that the RPS mechanism is a feasible method for increasing the diffusion of renewable energy sources into the electricity system. Moreover, it is reasonable to assume that the experiences of these 37-adopter states have established a body of information on the environmental and social conditions that catalyze adoption of RPS and the political processes that lead to their approval. The question then arises, in view of the experiences of 37 states, why does a block of the Southeastern United States not have this program in place? Could this particular region possibly have a better mechanism than RPS for achieving environmental health while acknowledging the importance of economic stability?

Narrowing the Research Scope

This thesis examines four hypotheses for explaining the absence of RPS.

1. Contrary to beliefs and assumptions, the experiences of the 37-adopter states show that RPS do not result, in practice, in an increased use of renewable energy sources for electrical generation. In other words, data among the 37 states may demonstrate increased use of renewables, but the increase was the result of "some other" mechanisms or conditions, not RPS. Thus, the Southeastern states may see no reason to adopt RPS if they do not prove useful in the experience of the adopting states.
2. There are not sufficient renewable energy resources in the Southeastern states to provide the electrical generation necessary for meeting RPS.

3. The organizational and technical infrastructure of the Southeastern states' electrical generation and distribution system makes RPS an impractical method for achieving increased renewably-derived electricity.
4. The political and social attitudes of the Southeastern states reject the need for renewable energy or, if they accept the need for renewable energy, they reject a government mandate, such as RPS, as a means of promoting their expansion into the electricity sector.

This thesis examines these four hypotheses within the state of Georgia, and ultimately concludes that the lack of RPS in Georgia is likely a combination of circumstances found within Hypotheses #3 and #4.

THE SOUTHEAST'S SIGNIFICANCE IN U.S. ENERGY

Before examining these four hypotheses, a foundational question must be addressed: Are the Southeastern states relevant in terms of their percentage of national energy consumption and carbon dioxide emissions?

According to the US Census Bureau, the Southeastern states include the following: Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Mississippi, and Tennessee. Only five of the above employ RPS mandates. Those that do not, and will be evaluated for significance are: Mississippi, Alabama, Georgia, Florida, South Carolina, Tennessee, and Kentucky.

These states represent about 17% of the total population of the United States, or 52 million people consuming electricity. In 2011, these seven Southeastern states without

RPS have electric sectors responsible for producing a significant proportion of their state's carbon dioxide emissions, according to EIA data.

State	Million metric Tons Carbon Dioxide for Electric Power	Electric Power's Share of State Carbon Dioxide Emissions
Alabama	74	57.5%
Florida	110	48.7%
Georgia	68	44.1%
Kentucky	94	63.4%
Mississippi	23	38.2%
South Carolina	38	48.7%
Tennessee	41	39.4%

Florida and Georgia are the fourth and ninth largest states (by population) respectively, and together comprise 9.23% of the national population and 7.08% of the nation's total carbon dioxide emissions. Coal, the "dirtiest" of the fossil fuels, is the most heavily used energy source within the electricity sector, and as previously stated, is responsible for 43% of the nation's generation (*Figure 1*). These seven non-RPS states alone produce approximately 18% of the total United State's coal emissions.

Total Net Electricity Generation Rankings by State, 2014 (thousand MWh)		
1	Texas	34,454
2	Florida	19,175
3	Pennsylvania	17,569
4	California	17,378

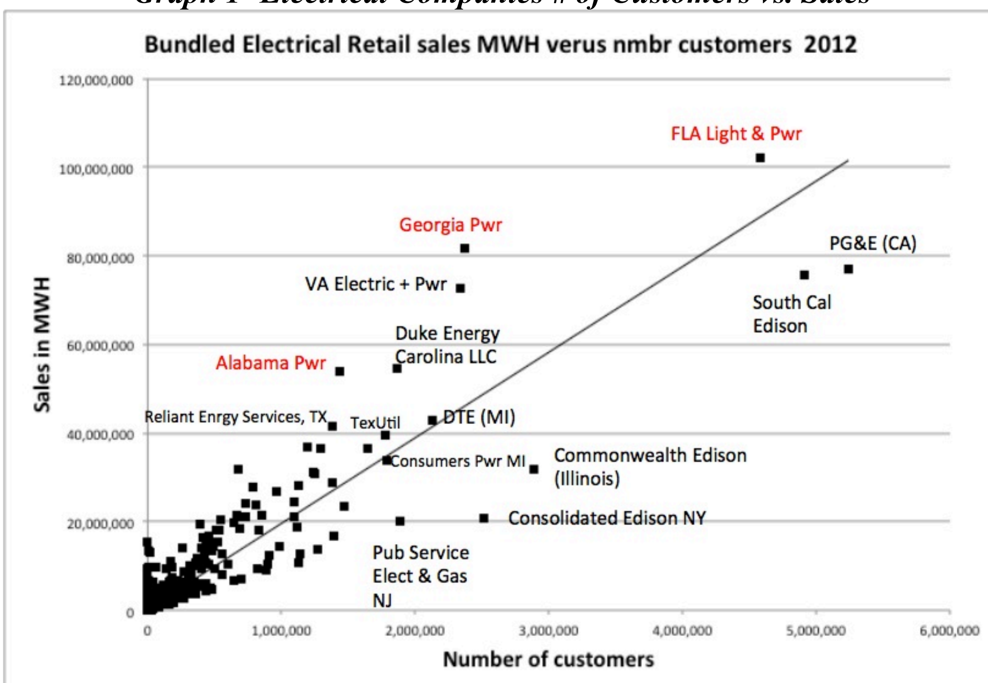
5	Illinois	15,876
6	Alabama	10,969
7	New York	10,919
8	Arizona	9,264
9	Ohio	9,020
10	Georgia	9,004

Moreover, according to EIA data, Florida, Alabama, and Georgia are among the top ten states with the highest total net electricity generation, collectively responsible for 39,148 thousand MWH. Beyond this, all seven of the Southeastern non-adopter states are within the top half of the country's generators and cumulatively produce 63,751 thousand MWH, 20% of the nation's net electricity.

Another perspective on electrical energy consumption within the Southeast is their per-capita electrical energy consumption is higher than national averages. The EIA annually tabulates electrical energy retail sales and the number of customers served by individual utilities. From these data, I plotted electrical energy sales as a function of number of customers for all the nation's utilities (*Graph 1*). The slope of the linear regression least squares best fit of electrical energy/customer estimates the national average per-capita consumption, which is found to be 20MWH/customer. The highlighted utilities, Georgia Power, Alabama Power, and Florida Light and Power, are chief generators for their respective states. The per-capita electrical energy sales of these utilities are considerably above the national average. This is probably due to the Southeast's hot, humid climate, because seasonal air-conditioning requires large amounts of electricity. By contrast, states with severe winters rely more heavily on heating by natural gas than by electricity.

Gathering these data together, the non-RPS states are collectively significant contributors to the total United States electrical energy production. Therefore, an examination of why these states have not adopted RPS is a substantial piece in the nation's energy standing.

Graph 1- Electrical Companies # of Customers vs. Sales

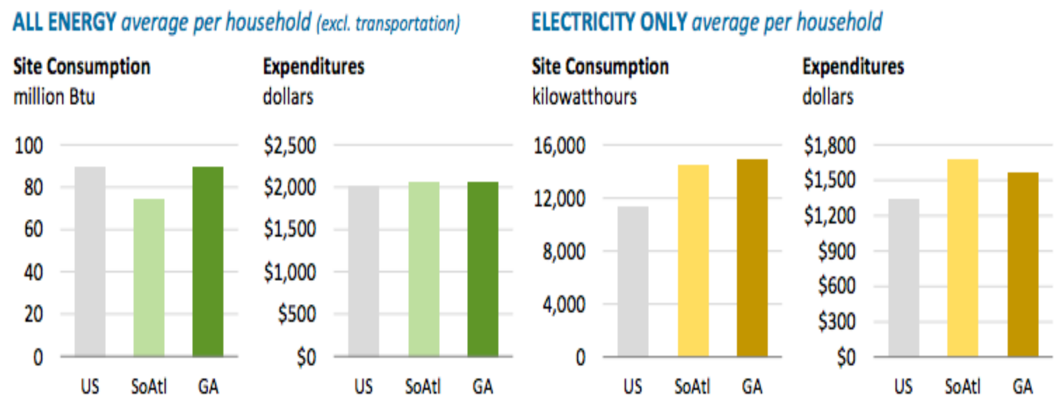


Georgia as a Case Study

Georgia, rather than Florida or Alabama, will be the representative focus of this research for several reasons. Firstly, Georgia's circumstances make it a more comprehensive case study than Alabama. Georgia's per capita electrical retail sales are higher than Alabama's, suggesting they more likely would benefit from RPS adoption. Georgia also has a larger total population, meaning that they will need to provide electricity for a greater number of customers, and this electricity will either be derived from renewable resources, fossil fuels, or nuclear.

Comparing Georgia with Florida, the latter's more complex geography and variety of climates prevents the formation of a statewide baseline for RPS evaluation. Florida spans about 6 degrees of latitude (450 miles), resulting in a high diversity of microclimates and potential renewables. The energy demands of Florida are similarly varied as a result of this climate range, diversity and distribution of population, and distribution of economic activity. Georgia by contrast, is more uniform in geography and climate, and the condensed Atlanta metropolitan area accounts for about 60% of Georgia's population. The majority of electricity will therefore be transmitted to Atlanta from nearby generating facilities. Additionally, according to EIA data, Georgia's electrical consumption is above both the regional and national average (*Graph 2)*. Furthermore, as discussed in a later section, the recent investment into nuclear power for Georgia's electrical infrastructure is likely to achieve greater carbon dioxide reductions than could be achieved by practical implementation of solar, wind, and biofuels. This additional variable of nuclear power poses a most interesting case study, weighing the success of nuclear power versus RPS in reducing carbon dioxide emissions. Delving into nuclear power, it must be noted that it plays a much larger role in Georgia than Florida in terms of the percentage of electricity it produces (EIA, 2014). Regardless, the geographic, social, economic, and demographic characteristics among non-RPS states are sufficiently diverse that the results of this study will likely not be applicable to all non-RPS states. The scope of this research is not wide enough to fully delve into the intricacies of each state's electrical production system, and I will therefore choose to focus on Georgia. The findings taken from this state can be used as an example and template for future examinations of other non-RPS states.

Graph 2- Georgia's Energy and Electrical Standing



HYPOTHESIS #1- The Effectiveness of RPS

Have RPS proven effective at increasing the consumption of renewably derived electricity among the 37 states that have adopted them? In principle, it is plausible that the Georgia energy-decision making process—whether State Legislature or State regulatory agencies—looked for and did not find evidence that RPS actually do increase renewable energy use. Due to the variation in policy stringency, goals, and resource capacity among states, the effectiveness of RPS is hard to assess. As an additional confounding variable, there is also a time lag of several years between adoption of RPS and implementation of renewable energy technologies, and RPS may not have been in place for a long enough time that their effectiveness can be sufficiently judged. The technical means for estimating the success of RPS is based on empirical, econometric or structural models, which are beyond the scope of this thesis project. In a study conducted by Shrimali et al. however, they have assessed several econometric models designed to explore this question of RPS effectiveness. Their research removed the influence of experimental outliers and tested the findings of previous publications with these models. Their results then yielded no definitive conclusion that RPS bring about an increase in the consumption of electricity generated from renewable resources.

Noteworthy in Shrimali et al.'s research is the finding that "the presence of RPS schemes in neighboring states apparently has a positive effect" (Shrimali et al., 2012). Therefore RPS approval by one state may influence the adoption of renewables for electrical generation by states in proximity. This occurs because, as one state increases their development of renewable resource technologies, they create an atmosphere conducive to further investment throughout their region. Therefore, a larger proportion of electricity is derived from renewables. This finding is significant after noting that the only states lacking RPS border one another, highlighting the importance of network effects (*Figure 2*). Although not an explanatory factor, this could play a role in the absence of RPS in the Southeast holistically

Their research also found that state income and wealth have a significant positive correlation with investment into technology that generates "clean" electricity. The outcome is logical, as states with stronger economies are better able to support entrepreneurs and companies who accept the higher upfront costs of purchasing renewable technologies and infrastructure. When evaluating the seven Southeastern non-adopter states, their economic rankings are as follows:

Overall Rank	State	Income Rank	GDP per Capita Rank
32	Georgia	32	37
38	Florida	37	46
41	Tennessee	44	38

46	Kentucky	47	44
48	South Carolina	45	49
49	Alabama	48	47
51	Mississippi	51	51

*Includes the District of Columbia

Each state falls within the lower half of the nation in terms of income and GDP ranking, diminishing their capacities to invest in costly infrastructure and electrical grid changes.

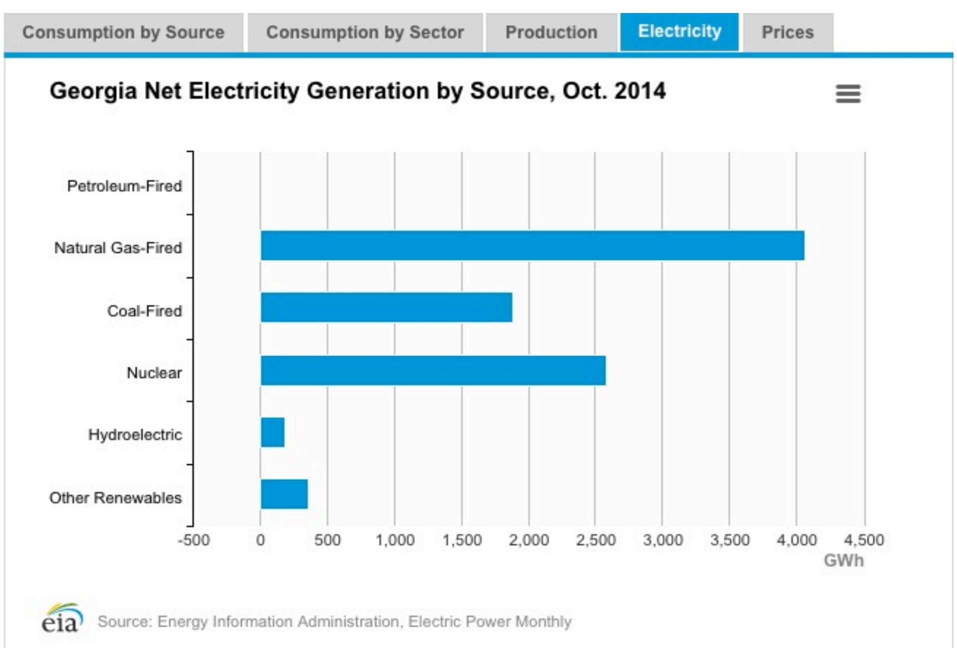
Lastly, Shrimali et al. found that states with political atmospheres that previously supported types of environmental policies other than energy have significantly higher levels of renewables-derived electricity development than those without. This final factor may play a significant role in explaining the Southeast's lack of RPS, as the political climate has been strongly conservative in recent history—a point discussed beneath Hypothesis #4.

In summary, published econometric analyses of RPS are inconclusive in their attempts to establish the effectiveness of RPS toward achieving greater development of renewable energy technologies, and consequentially in mitigating carbon dioxide emissions. Their study suggests, however, that as the 37 states continue their RPS mandates, they may have future influence, in non-obvious ways, in furthering the adoption of renewable energies. We can conclude therefore, that Hypothesis #1 cannot be the reason for the absence of RPS, because there is no evidence that they are indeed ineffective. Finding ambiguous results, RPS remain a plausible political tool for requiring investment into renewable technologies.

HYPOTHESIS #2: Georgia's Renewable Resource Potential

A primary consideration in evaluating RPS is the solar, wind, and biomass resources available in the state. National accounting of renewable energy (figure 1) includes hydroelectric generation. In figure 1, renewable sources are: solar (0.8 Q), hydro (2.53 Q), wind (1.6 Q), geothermal (0.16 Q), biomass (0.46 Q) for a total of 5.25 Q. The latter is 13.7% of total U.S. primary energy used in electrical energy generation. Very few states have any opportunities to further expand hydroelectric capacities because there are no remaining sites. Thus nationally, renewables excluding hydroelectricity currently account for about 6% of the U.S. total primary energy for electricity generation. Thus assessment of RPS resources needs to exclude hydroelectricity. In Georgia, hydropower potential (rivers on which dams can be built) is largely tapped out and the state obtains about 4% of its electricity from renewable resources after excluding hydroelectricity.

Graph 3- Electrical Generation by Source



Estimating Georgia's Renewable Resources

The following sections estimate the technical potential of these resources, not their economic or political viability. Most RPS are ultimately expressed as a fraction of the state's retail sales. The RPS are aimed at replacing fossil-fuel energy, so the estimate begins with determining the electrical energy currently produced by fossil fuels. Important to emphasize however, is that RPS goals are expressed as a fraction of the delivered electrical energy at retail, not the energy required to produce that electrical energy. While electricity produced by fossil fuel combustion is about one-third of the energy released by this combustion, due to the inherent thermal inefficiency of heat engines. An additional confounding factor when comparing RPS between states is that some specify renewables as a fraction of electrical generating power capacity (megawatts). This means that if a state has a capacity to produce a certain amount of megawatts from renewables, but never employ this capacity, nothing will be achieved.

In 2014, Georgia's retail electrical energy was 131 million MWH. About 4% comes from non-hydro renewables. Nuclear power plants generated about 23% (30 million MWH). (Nuclear power in Georgia is examined in detail in a later section in the context of its importance for RPS.) Thus the "target" for RPS in Georgia is about 100 million MWH.

Suppose that we aimed for a future goal of 15% from renewables, in line with many state's RPS. Thus we seek to generate 15 million MWH from renewable resources. We will estimate the requirements for solar, wind, and biomass, individually and ask, what is required if that one source had to produce 15 million MWH. After running the initial calculations, the problem of generating clean energy for an RPS evolves into a land-use and space problem.

Solar Power in Georgia

The estimate for "solar" is based on current technology silicon solar panels (photovoltaic effect.) The calculation proceeds as follows. We use National Renewable Energy measurements for the solar power (watts)/square meter incident at an appropriately oriented surface, averaged over 24 hours, and over a year. The average power multiplied by 24 hours yields the energy collected in 24 hours. The NREL data are expressed as (kilowatt hours)/(square meter of solar panel area) in 24 hours. About half of the incident solar energy cannot be converted to electrical energy either because its energy is less than the band-gap of silicon or its energy is in the range where fundamental physical limitations inherent in the photoelectric effect limit the conversion efficiency. As is conventional in the solar panel industry, we assume that about 10% of the potentially effective solar energy can be converted to electrical energy by practical devices in the field.

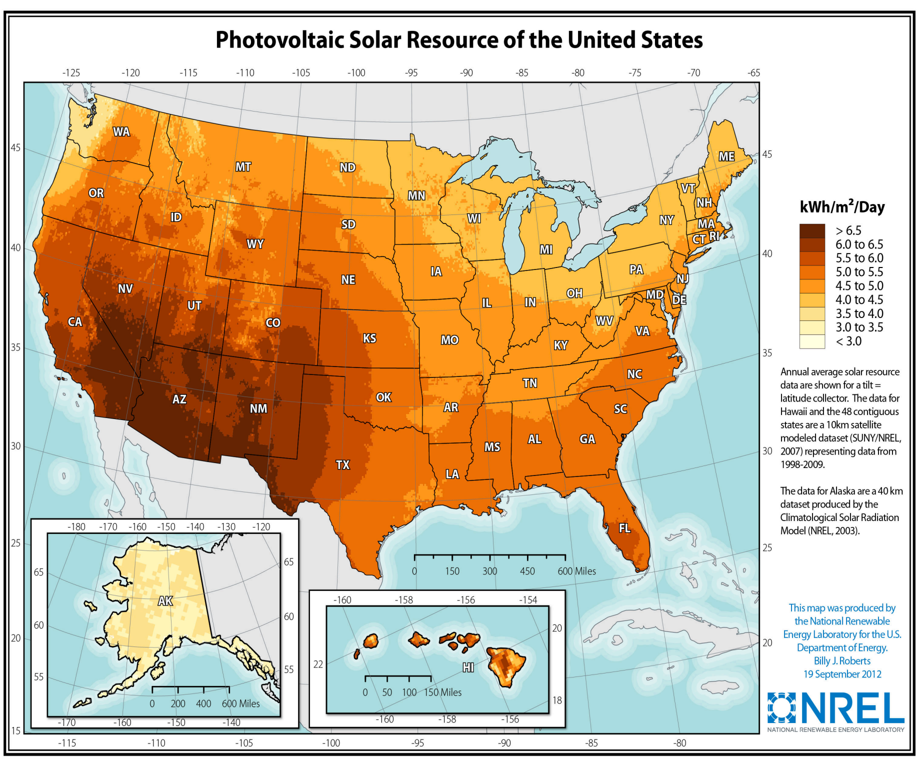
NREL data (*Figure 3*) show for Georgia a photovoltaic resource in the range of 5 to 5.5 kwH/m^2 /24 Hour day. As described in the above paragraph, about half the energy fulfills the conditions for generation of photocurrent, and the efficiency of that latter conversion is about 10%. Thus solar panels can produce about 0.50 to 0.55 kwh/m^2/day. In terms of a 15% RPS the question becomes how much land area would be needed for a utility-scale solar farm to supply the 15 million MW?

In one year, on average, solar panels would deliver about .0055 MWH/day/m^2 of electrical energy, which corresponds to about 0.182 MWH/m^2 in 1 year. Thus, 15 million

MWH annual electrical energy, divided by the 0.182 MWH/m^2, the annual electrical energy produced by 1 square meter of solar panel, yields 82 million m^2 of solar-panel area.

As a means of getting an intuitive sense for 82 million square meters of solar panel, assume that the main customer for this electrical energy is Atlanta. The land area of the Atlanta Statistical Metropolitan area (population 6 million in 39 counties) is 27,000 km^2 (27×10^9 m^2) (U.S. Census Bureau, 2015). Thus a solar farm with panel area of 82 million square meters would occupy about 0.3% of Atlanta metropolitan land area ($82 \times 10^6 / 27 \times 10^9 = 0.003 = 0.3\%$). In practice the land area occupied by utility scale solar farms is about double that of the solar-panel area. So a utility scale solar farm would require 0.6%--call it 1% of the metropolitan Atlanta land area.

Figure 3- Solar Resource Potential Across the United States



Wind Power in Georgia

In determining the potential for wind farms to meet Georgia's RPS of 15%, the question is the number of wind turbines required. Nameplate capacity, or the maximum amount of energy that can be generated under ideal conditions, is currently 2.5MW for the state-of-the-art commercially available wind turbines. Under actual operations, turbines operate, averaged over the year, at less than capacity. Economically viable wind-farms typically operate with a yearly average "load factor" (actual power output/name plate) of around 30%, except in a few places (e.g. Texas) where it approaches 40%. Therefore, on average, one wind turbine produces approximately 0.75MW. Over a year's time, 8760 hours, a single wind turbine could deliver 6750MWH. Therefore, generating 15 million MWH would require a minimum of 2300 wind turbines.

The land area required for an on-shore wind turbine ranges from 25-100 acres per turbine, which includes the necessary infrastructure like roads, service areas, etc. (NREL). Current best technology is 100-meter diameter rotor (propeller) and generator assembly mounted on a 100-meter tower. Wind turbine placement depends on the geometric configuration (lines versus grid); in grid configurations, about 100 turbine blade diameters spacing is necessary to avoid wind-flow interference between turbines. Assuming a fairly uniform terrain, at 50 acres per turbine, 2300 turbines x 50 acres= 115,000 acres. This 115,000/3,800,000 acres, is equal to 3.73% of Georgia's total land area.

	Offshore Wind	Onshore Wind
GA's potential	220,807,000 MWH	323,000 MWH

Returning to the NREL data, the onshore wind potential energy is 323,000 MWH. Applying the hypothetical RPS standard of 15%, onshore wind has the potential to generate about 2% of the 15 million MWH**.** The above onshore wind data, however, was limited to areas with an annual gross capacity factor of 30% or greater from average utility scale wind turbines at 80-meter heights. Offshore wind measurements were made at heights of 90-meters and within 50 nautical miles of the United States coastline. Including these offshore wind sources greatly increases wind power's potential, swelling to 220,807,000 MWH. Cumulatively, a combination of onshore and offshore wind turbines could generate 221,130,000 MWH. Meeting the RPS standard would require 14.72% of this total energy.

BioMass in Georgia

Biomass, plant-based organic materials, can be used to obtain energy either directly (by burning it) or indirectly (by converting it to a liquid or gaseous fuel). Combustible wood and grass biomass are essentially cellulose/lignocellulose, the standard enthalpy of combustion (kjoule/gram) of which is about 60% that of high-grade coal. As a direct energy source it is combusted to generate heat. Indirectly, biomass is converted to biofuel chemically, thermally, or biochemically (for example, ethanol via fermentation, methane via anaerobic digestion). Deriving the greatest amount of energy possible from biomass requires a fast growing, cultivatable dried plant to substitute for coal or natural gas. Subsequently, the question is: How much land area will be required to grow enough of a biofuel to generate 15 million MWH?

This study will focus on switchgrass, a common contemporary biofuel. To keep costs low, switchgrass farming would minimize expensive synthetic fertilizers, and natural rain will assumedly be sufficient hydration. Switchgrass' yield, measured under controlled study conditions, ranges from 3-10 tons of drymass/acre depending on where it is grown. For purposes of estimating in this thesis, we use an average yield of 5 tons of drymass/acre (Vogel et al., 2002). This converts to 4500kg/acre. Complete combustion of switchgrass produces about 15 megajoules/kg. Therefore, 4500kg/acre x 15MJ/kg= 67500 megajoules/acre. Since 1-kilowatt hour is the equivalent of 3.6 megajoules, therefore, 67500 megajoules x KWH/3.6mJ/acre= 18,750 KWH/acre = 18.75 MWH per acre of land. Using conventional thermal electrical generation, roughly 30% of the combustion energy can be converted into usable electrical energy. Therefore, the effective electrical energy is approximately 6 MWH per acre. Thus, achieving 15 million MWH of electrical energy (15% of the total Georgia production) by biomass alone would demand 2,500,000 acres of switchgrass. Singularly, this entails 2,500,000/38,000,000 acres, or 6.57% of Georgia. It must be noted however, that this figure does not account for energy loss during harvesting the biomass, processing/drying it, and shipping it to the generator.

The NREL chart below further illustrates the higher efficiency of utilizing a solid biopower, like switchgrass, over a gaseous biopower. Referencing both the below NREL data as well as the above calculation, it would take from 2-2.5 million acres to generate 15 million MWH. These calculations suggest that biopower should not be used as the sole renewable resource, but instead to augment other fuels when the land and farming prerequisites are available.

	BioPower- Solid	BioPower- Gaseous
GA's potential	14,682 GWh	2,221 GWh

Hydropower in Georgia

Hydropower as a renewable resource in the scope of this study will be excluded for the following reasons: 1) Hydropower has largely been utilized to its utmost extent and offers little increased potential in the future, as there is a lack of opportunity for future growth along the coast. 2) Many hydropower facilities are being closed due to outdated equipment and inefficiency. 3) The economic costs required to update Georgia's existing hydropower facilities are high, discouraging further development.

Total Renewable Energy Analysis for Georgia

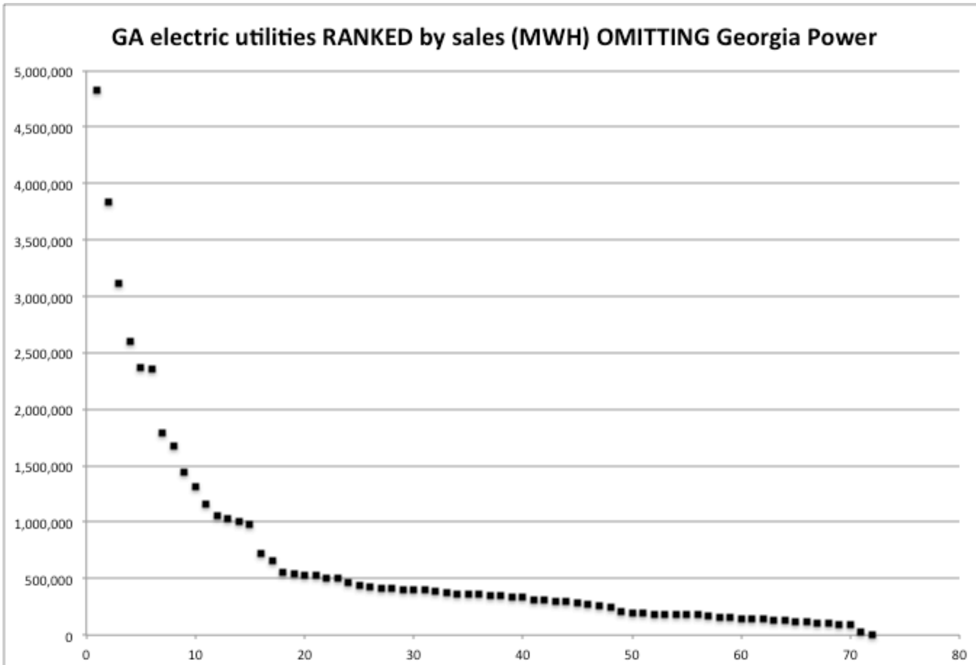
Cumulatively, by combining the energy that could be obtained through solar and wind's nameplate capacities, Georgia could generate 15 million MWH by constructing farms for these renewables on about 4% of the state's land area. The greatest hindrances to achieving the renewables-derived electricity necessary for RPS are therefore the economic expenses and land-use complications. The cost of building and maintaining a utility-scale solar farm for large-scale generation would be in the billions. A single wind turbine costs anywhere from $1-3 million, and a few thousand of them would also entail an investment of several billion. Offshore wind however, is likely to be more expensive and is a largely underdeveloped throughout the United States. The strategy for applying wind power for an RPS would therefore need to consider the energy and fiscal tradeoff between investing in onshore versus offshore wind turbines.

While large tracts of land would be necessary to achieve a 15% reduction in fossil fuel generated electricity, it is unclear if this has been an operational disincentive for RPS in Georgia. I was unable to find any publically available document that invoked land-requirements as a disincentive. It may be the case that consideration of RPS in Georgia never got far enough to even think about the land-requirements. My analysis shows that upfront investment in renewables demonstrates would require a high upfront investment, but Georgia possesses the technical capacity to generate substantial proportions of clean electricity by integrating their various resources. However, it must be noted that resource potential is not the same as the resource itself. Conversion rates, technological efficiency, differences in geography and resource quality must be assessed. Even after noting these variables however, an RPS goal could be achieved through a mixture of solar panels, switchgrass combustion, and offshore wind power. Acknowledging realistic constraints, these three sources in particular could provide Georgia with a substantial proportion of its electricity consumption demands.

HYPOTHESIS #3: Structure of Georgia Electrical System Today

Georgia Power, a wholly owned subsidiary of Southern Company, supplies approximately 62% of Georgia's electricity, with the majority of their customers in the Atlanta area (GAPower, 2015). The rest of Georgia's electricity is generated by 40 cooperatives and 29 municipals, mainly located in rural Georgia. The retail energy sold and the number of customers of cooperatives and municipals span a wide range. Cooperatives play a larger role than municipals in the state, quadrupling them in the amount of retail energy sold. Furthermore, these cooperatives and municipal suppliers can either generate their own electricity, or purchase it from larger generating corporations.

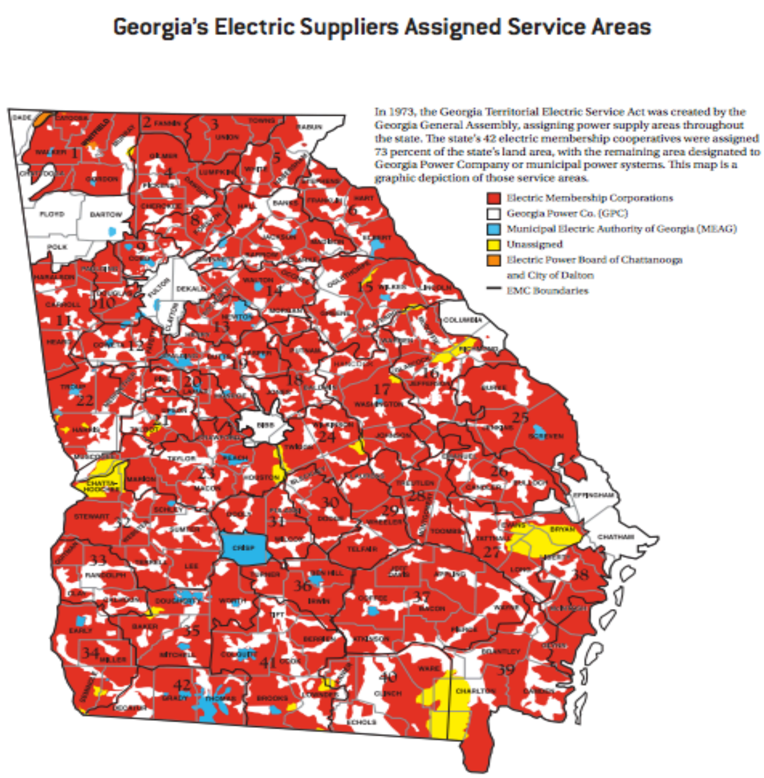
Graph 4- Georgia's Electric Utilities Ranking



The Role of Cooperatives and Municipalities

A challenge to implementing an RPS would be the role of regulation over small-scale utilities. How could they be ordered to obtain a percentage of their electrical generation from renewable resources if they have neither the storage capacity nor financial ability to invest in solar, wind, or biomass technology? Yet, they generate electricity for 1/3 of the customers throughout Georgia. It is difficult to envision an RPS mechanism that would equitably bring the cooperatives and municipals under the same regulation that is imposed on Georgia Power. While administration would pose a challenge, there are several routes for bringing these groups under an RPS mechanism. Georgia State government could provide fiscal packages to help shoulder a proportion of the upfront cost of developing renewable technologies, easing the challenge of transforming their current methods of electrical generation. These fiscal incentives would require the reapportionment of existing tax revenues, but the passing of such legislation may be politically unfeasible. In the context of this thesis, the structure of Georgia's electrical industries may present the barriers that would make such policies, which would ultimately support RPS, politically insurmountable. Additionally, as cooperatives and municipalities already often purchase electricity from larger corporations and then distribute it to their customers, an RPS could require them to only purchase electricity generated from clean sources, instead of obliging them to generate it independently. Lastly, where several cooperatives are concentrated in certain regions, they could be held collectively responsible for generating a pre-determined percentage of clean electricity (*Figure 4*). Some companies generating more clean energy than others could also sell their rights to those generating solely through fossil fuels. Therefore a small-scale exchange system could arise, facilitated by permits and an overall reduction objective.

Figure 4- Distribution of Georgia Electrical Supplier's



Cooperatives and municipalities would have to be regulated by an RPS, as neglecting to include them would place a larger burden upon Georgia Power, to generate clean energy. Georgia Power would then almost undoubtedly reject an RPS, and because they have a larger political clout than the smaller companies, the legislative likelihood of the mandate passing would diminish.

Nuclear Power Development in Georgia

Nuclear powered electric energy-generation process produces no greenhouse gas emissions and accounts for about 20% of the primary energy used for electricity generation in the U.S. (*Figure 1*). Although nuclear energy is "clean" in the sense of carbon dioxide emissions, it is not classified as renewable because uranium and other fissionable elements suitable for fueling electricity generation are in the long term not renewable, and nuclear fission has very long lived radioactive waste. Despite this, Georgia Power is currently in progress to open in 2017 two nuclear power plants, Vogtle units 3 and 4 that will each add 1700 MW (nameplate capacity). Thus the two plants together will have the capacity for generating about 30 million MWH; a typical annualized load factor of 80% (combination of season fluctuations in demand and necessary operating down-time) will yield about 25 million MWH of "new" power—10 MWH more than a 15% RPS.

The new generators will be jointly owned by four Georgia-based electrical companies- Georgia Power (45.7%), Oglethorpe Power Corporation (30%), Municipal Electric Authority of Georgia (22.7%), and Dalton Utilities (1.6%) (GAPower, 2015). Oglethorpe Power's co-ownership, as they are already an Atlanta-based supplier, suggests that a large proportion of the newly generated electricity will be transmitted to the metro-Atlanta area. Oglethorpe Power's role as a supplier simply means they distribute electricity to their customers that was generated elsewhere. A generating company by contrast, produces electrical energy itself. Construction of Vogtle 3 and 4 is overseen by Southern Nuclear, which in turn is owned by Southern Company, a holding company that also owns Georgia Power. Southern Nuclear has previously been responsible for six nuclear units in co-operation with both Georgia Power and Alabama Power. Theoretically then, the newly generated electrical energy could be sold among varying subsidiaries of Southern Company, although transmissions would likely be limited predominantly to Alabama and Georgia.

Nuclear Power, Georgia Power, and Southern Company

Southern Company already has an established history of nuclear generation, and through its subsidiaries meets 16% of its energy demand through such production. They operate all four of Georgia's nuclear facilities, two of which, Plants Hatch and the original Vogtle, collectively provide about 20% of the state's electricity. Also in Georgia, two new facilities, Vogtle 3 and 4, are being constructed. Beyond this however, there are three main facilities currently in operation, housing six nuclear reactors total. These are the Alvin W. Vogtle Electric Generating Plant, the Edwin I. Hatch Nuclear Plant, and the Joseph M. Farley Nuclear Plant.

Vogtle and Hatch cumulatively produce 18% of Georgia Power's electricity, and with the new additions of Vogtle 3 and 4, Southern Company declares future prospects to be even higher. This prospect of zero emissions, coupled with increased generation potential, could specifically appeal to Georgia Power and Southern Company after being ranked as one of the top emitters in the nation in recent years (*CGD, 2007*).

After heavily investing into nuclear power, the imposition of an RPS would be unappealing to Georgia Power. Increased nuclear energy generation, as it is not a fossil fuel, would mean that a smaller percentage of the state's electricity is being produced by fossil fuels, and the target of RPS would be that much harder to attain. With the construction of Vogtle 3 and 4, as well as investment into developing existing nuclear technology, Georgia Power, and the overarching Southern Company, has no incentive to accept RPS. Once the two plants are functioning, the carbon footprint for Georgia Power's generation will be reduced to the extent that the need for more expensive alternatives, such as renewables and RPS, will be negated.

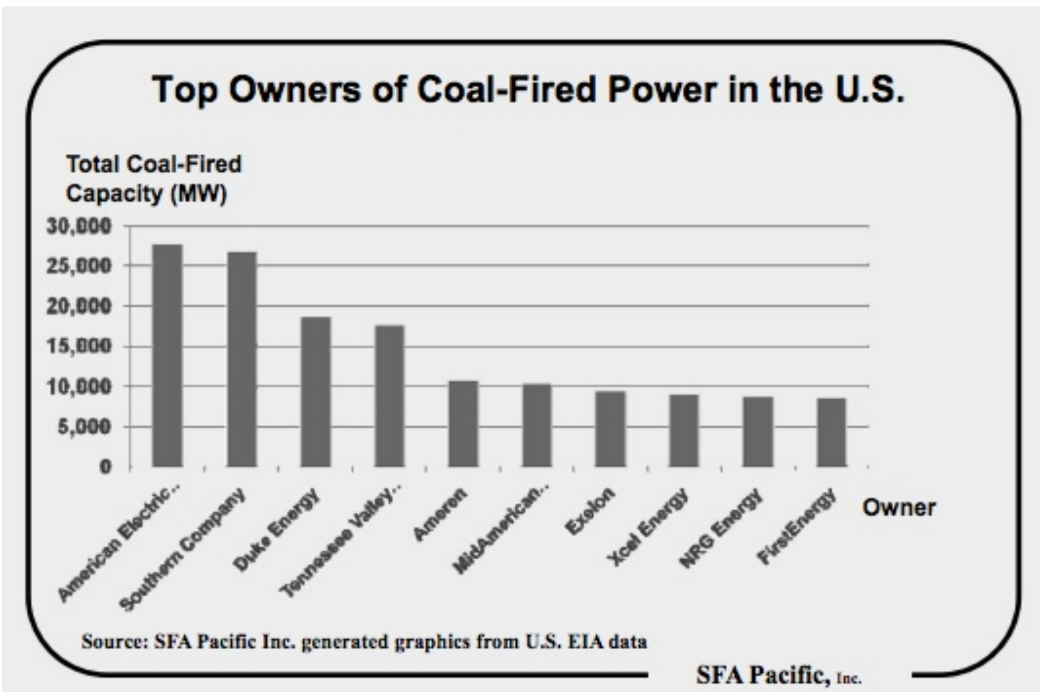
Economic Hurdles to RPS

As previously discussed by Shrimali et al., a possible reason for Georgia's lateness in adopting RPS is the large financial burden incurred by constructing power plants designed solely to utilize renewables. Although 37 other states have implemented such facilities, Georgia's financial load may be more difficult after their recent investment into the Vogtle project, coupled with the Great Economic Recession in 2008. After paying in the billions for both construction and financing expenses, investors do not gain their returns until utilities are functional and serving customers. Additionally, Georgia Power is already observing the state-mandated Environmental Compliance Cost Recovery (ECCR) tariff. By the tariff's regulations, companies are compensated for the extra expenses they incur meeting environmental standards set by state and federal regulations. While this lessens the economic challenge of outfitting Georgia's current electrical companies with clean energy technology, it negates the incentive to construct new and entirely renewable facilities intended to achieve RPS objectives.

The Conflict with RPS

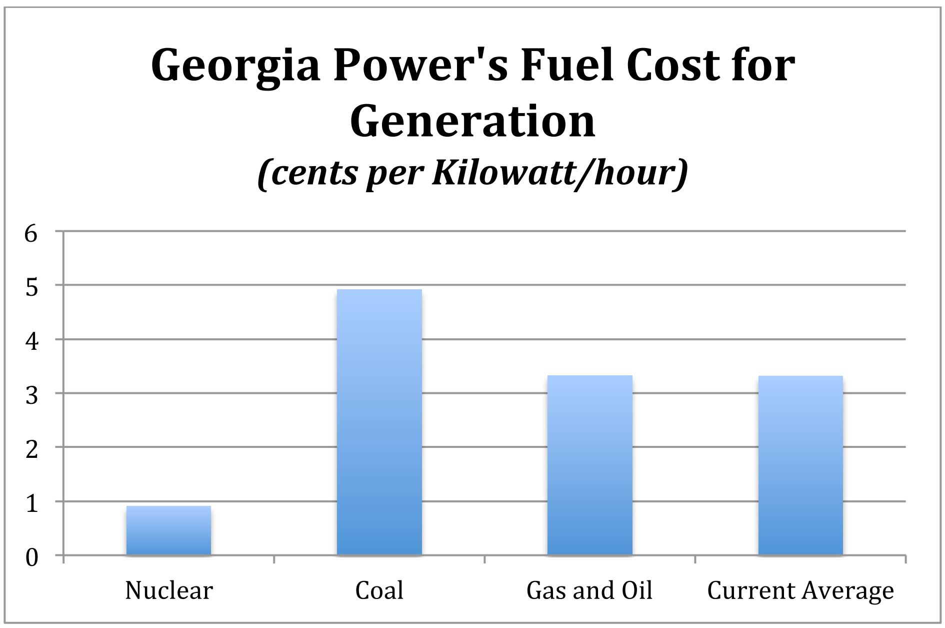
A feasible RPS objective would inevitably be aimed at the coal-dependent generators. Coal-fired power plants initially seem to require less land because the utilities themselves may cover only about a square mile, but land-use increases drastically after accounting for the total land-use footprint that includes coal mining for a coal-fired plant. Coal mining is a land intensive process, and can cause mountaintop removals, and the degradation of large tracts of land.

Graph 5- Top Coal-Generating Companies in the U.S.



In 2011, Southern Company (Florida, Georgia, Alabama, and Mississippi), Duke Energy (North Carolina), Tennessee Valley (Tennessee), and NRG Energy (Texas) were some of the most coal-dependent electrical energy producers in the nation (*Graph 5*). In Southern Company's case this results in a coal-fired capacity of over 25,000MW. Although not directly mined in Georgia, by reducing the amount of coal-combusted electricity on a regional level, land formerly used for coal generating facilities or mining in other Southeastern states could be repurposed for solar or wind farms. The energy from these farms could then hypothetically be sold and transmitted to Georgia. Considered from another perspective, electrical generation via coal is more expensive for Georgia Power than nuclear, gas, or oil (*Graph 6*). A cutback in coal combustion could therefore provide a fiscal buffer for the creation of clean energy infrastructure. Consequently, the challenge for renewables generation is reduced to a more manageable scale.

Graph 6- Georgia Power's Fuel Cost by Source



Reviewing these variables, findings suggest that Georgia, and notably Georgia Power's recent investment into nuclear energy through Vogtle 3 and 4, provide substantial disincentives for RPS adoption. Their heavy support for this alternate means of energy generation, coupled with a daunting challenge in transitioning the existing electrical utilities and regulating small scale cooperatives and municipalities, could effectively discourage the adoption of RPS in Georgia.

HYPOTHESIS #4: A Hindering Political Atmosphere in Georgia

Georgia's Political Background

The Republican Party has controlled Georgia's government in recent years, evident in Governor Nathan Deal, and his fully Republican board of elected officials. Acknowledging this, it must be noted that Democratic groups are often much more favorable to passing environmental legislation than Republican groups. Furthermore, the dominance of a state's Democratic party is found to be a key explanatory variable for RPS adoption (Lyon and Yin, 2010). Gathering the political will to pass ambitious legislation, like an RPS, often requires the presence of political actors motivated by their personal beliefs. There has not been in Georgia a political entrepreneur emphasizing RPS, and this lack could be a key factor in explaining the absence of RPS. Is it simply a lack of powerful pro-RPS politicians and industrial interests, or is there actually a mentality of opposition throughout the state that greatly increases the challenge of RPS adoption? This final hypothesis will delve more deeply into this inquiry.

Southern Company Background

As previously mentioned, Southern Company is a holding company that owns Georgia Power. Cumulatively, Southern Company through its wholly owned subsidiaries serves 4.4 million customers in 4 states, and sells 183,400,000 MWH. Southern Company is currently the 16th largest utility company in the world, and the 4th largest in the US.

In a 2007 report released by the Center for Global Development, Southern Company was the largest GHG emitter in the United States utility industry, with 172 million tons of carbon dioxide equivalent gases emitted annually (CGD, 2007).

As a whole, Southern Company has reduced their coal-fired emissions more than 70% since 1990. This decrease stems from a transition to natural gas-fired plants and the lower electrical generation rates that followed the country's economic downturn in 2008 (SouthernCompany, 2015). Adding further increases to their clean energy production, Georgia Power adopted an Advanced Solar Initiative (GPASI), which created a volunteer solar portfolio from an investor-owned utility. By the GPASI, the company was given the goal of generating an additional 201MW beyond what they currently produce from solar energy. This number however, is insignificant on the scale of statewide electricity demand, and may be more of a political statement than a genuine push for renewables-derived energy. If Georgia Power were serious about pursuing cleaner energy and initiatives, why would it not encourage the acceptance of an RPS?

The absence of RPS can potentially be traced back to Southern Company, as they are the parent electrical industry that would be most heavily impacted by the mandate's implementation. This corporation is the owner of four subsidiary companies: Georgia Power, Alabama Power Company, Gulf Power Company, and Mississippi Power Company. These vertically integrated utilities are responsible for electricity generation in Florida, Mississippi, Georgia, and Alabama, which are four of the states lacking RPS (SouthernCompany, 2015).

Company	**# Of Customers**	**Electrical Generation (MWH)**
Georgia Power	2,396,537	84,700,000
Alabama Power	1,444,809	58,637,410
Gulf Power	439,783	2,333,984

Mississippi Power	186,490	1,4592,000
Southern Company (*Total*)	~4,400,000	183,400,000

Data from the US Census Bureau illustrates the significance of Southern Company in generating electricity throughout the Southeast. In both Georgia and Alabama, around ¼ of the states' populations are dependent upon the corporation's transmittance of energy to their varying subsidiaries.

State	Population	Electrical Consumption (MWH)
Georgia	9,992,167	82.35
Alabama	4,833,722	115.76
Florida	19,552,860	61.55
Mississippi	2,991,206	379

Further analyzing this, Southern Company is responsible for:

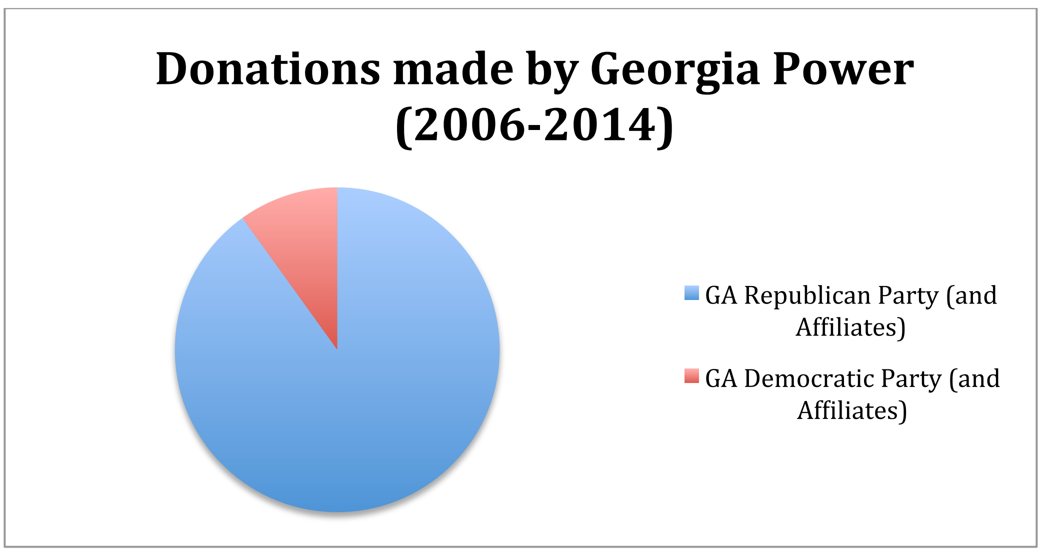
Southern Company Subsidiary	% Population Served
Georgia Power	23.98%
Alabama Power	29.89%
Gulf Power	2.25%
Mississippi Power	6.23%

Georgia Power's Political History

Georgia Power is a microcosm of the state's partisan standing, guided by political preferences that appear to incentivize an investment into nuclear power development over renewables. The Democratic and liberal agenda has consistently been more favorable towards environmentally beneficial policy, such as RPS, while the conservative GOP has prioritized economic security. Seemingly confirming this, in prior election years Georgia Power has made significant contributions to the Republican Party of Georgia, and comparatively small contributions to the Democratic Party.

Georgia's Transparency and Campaign Finance Commission publish all political contributions, including those donations made by corporations. In a report detailing 304 political contributions made by Georgia Power, there were twenty-nine donations to partisan groups. Of these twenty-nine, twenty-six were received by various Republican groups, while three went to the Democratic Party of Georgia.

Graph 7- Georgia Power's Political Contributions



Georgia Power has given cash gifts to numerous Republican affiliates, markedly the Georgia Republican Party, the Henry County Republican Party, Georgia House Republican Trust, Inc., Georgia Republican Senatorial Trust, and the Georgia Republican Senatorial Committee. In contrast, the three donations received since 2006 by the Democratic Party in Georgia went solely to the Democratic Party. Roughly $181,430 was contributed to the Georgia Republican Party, while only $20,000 was given to the Georgia Democratic Party by comparison (Georgia.gov, 2015).

Political Leanings of The Southern Company and Georgia Power

As the largest subsidiaries of Southern Company, and the producer of the majority of Georgia's electricity (62%), Georgia Power's theoretical alignment with the Republican Party could effectively hinder legislative approval for RPS in the state. A significant advocate against RPS and clean energy standards is the American Legislative Exchange Council (ALEC). The group has claimed that RPS adoption results in negative economic and environmental externalities. Their argument is that corporations and utilities are not driven to purchase higher than necessary proportions of clean energy once RPS has been adopted (ALEC.org, 2014). Furthermore, ALEC is a strong supporter of aiding nuclear power facilities through the lobbying effort Nuclear Matters. Interestingly, a supporting member of ALEC is Southern Company (Energy&Policy, 2015). Therefore, although Southern Company's relationship with Georgia's Republican Party remains speculative, their connection with pro-nuclear and anti-RPS affiliates is not.

	GA Republican Party	**GA Democratic Party**
Georgia Power Political Contributions	$181,430	$20,000
Percent of Total Partisan Group Contributions	90.07%	9.93%

Returning to Nuclear Power

Significant in this research, nuclear energy is today a right-wing platform, as environmental groups heavily oppose the creation of nuclear facilities and their radioactive waste. Nuclear power can be appealing because of its freedom from fluctuating markets, offering a reliable source of income to Georgia Power, a security that would be initially favorable to the dominating Republican Party. In a strictly structural sense, nuclear plants have infrastructure costs comparable to those of more conventional generating facilities. However, after including regulatory expenses and the construction requirements to handle long-term radiation exposure, the upfront costs of creating a nuclear facility are 10x greater than that of a conventional thermal plant. But once in place and operating, nuclear power plants are cheaper than conventional thermal plants. Moreover, if at some future date, conventional thermal plants will by regulation be required to capture and sequester carbon dioxide, the nuclear plants will likely have a very large, operational cost advantage over thermal plants.

Investors bear the burden of the “carrying cost”, or upfront capital that cannot be returned until revenue is generated. Here is where supporters like ALEC can be pivotal, providing initial investment for struggling nuclear facilities. If the expenses incurred by the political and nuclear power plant siting process could be lessened, or the process of creating a new facility expedited, the construction of a new nuclear utility may be economically competitive compared to fossil fuel generating facilities. As the GOP agenda is typically more economically focused, this could be an enticement to transition to nuclear power over more costly wind and solar farms.

CONCLUSION

Renewable Portfolio Standards have become a key state-level policy tool aimed at mitigating carbon dioxide emissions and legislating a transition to the use of renewable resources for electrical generation. As this tool has been implemented in 37 states across the nation, their potential significance cannot be ignored. Yet, as Shrimali et al. found (Returning to Hypothesis #1), studies have been unable to demonstrate that RPS adoption has caused increased use of renewables. These studies are complicated by outlying variables and the short history of implemented RPS—their implementation may not have had sufficient time to yield results that would arise in research. Incidental to the direct impacts of RPS, Schrimali et al. found that network effects, a state's economic strength and previous political atmosphere are explanatory in addition beyond simply RPS in the implementation of renewable energies. Consequentially, RPS cannot be discounted as a means for reducing carbon dioxide emissions and both adapting to and mitigating climate change.

When considering Hypothesis #2, technically, although limited economically, there are sufficient environmental resources available to meet Georgia's electricity demands via renewables. Adopting a modest RPS, a 15% reduction goal, is therefore a viable possibility and not the reason for RPS's deficiency. Upon delving into prerequisites for these resources to provide sufficient generation, the question of an RPS quickly evolves into a question of land availability. Even accounting for this, the results showed the strong potential of both wind power and solar power, augmented by biomass in the form of switchgrass, to support at least a 15% RPS mandate.

Georgia's current electrical organizational and technical structures, evaluated in Hypothesis #3, delve into the conflicting reappearance of nuclear utilities. Nuclear power, particularly the creation of Vogtle plants 3 and 4 by Georgia Power, offers an alternative option to RPS toward achieving the specific goal of reducing carbon dioxide emissions.

The corporation can produce their necessary MWH to meet consumer demand, 81 million MWH, and supplement it with their previous generation methods. By focusing efforts on this means of generation, Georgia Power, and by association Southern Company, are able to lower emissions and gain the commercial label of being “green” and innovative without incurring the high upfront costs of renewables infrastructure, or placing themselves within political constraints.

As Georgia Power’s focus has been to invest in nuclear energy, and their political inclinations have been dominated by the Republican ideology in recent history, the adoption of RPS appears unlikely when compiling data within Hypothesis #4. Hindered not simply by the lack of a political entrepreneur advocating for RPS, but by the support of a political party that historically obstructs environmental legislation, the state policy tool has little foundation upon which to build support in Georgia.

Based upon the findings of this research, the absence of a RPS in Georgia appears to be the accumulation of predominantly two factors within Hypotheses #3 and #4. Georgia’s investment into nuclear power, coupled with a political atmosphere that would deter the success of passing environmental legislation, supplemented by Georgia Power and Southern Company’s control in generating and transmitting electrical energy throughout the Southeast. Although RPS still have the potential to be adopted throughout the Southeast in the future, political, economic, and environmental hurdles will need to be overcome before their likelihood of proposal and implementation make them a feasible political tool for addressing the dangers of climate change and carbon dioxide emissions.

WORKS REFERENCED

"Annual Energy Review." *US Energy Information Administration*. Independent Statistics and Analysis, Oct. 2014. Web. Dec. 2014.

Bernardo, Richie. "2014′s Richest and Poorest States." *Wallet Hub*. WalletHub, Jan. 2015. Web. 11 Feb. 2015.

Carbon Disclosure Report. Rep. Southern Company, 2014. Web. http://www.southerncompany.com/what-doing/pdf/Carbon_Disclosure_Report.pdf

"CGD Ranks CO2 Emissions from Power Plants Worldwide." *Center for Global Development* (2007): n. pag. *EurekAlert*. Web. Nov. 2014. http://www.eurekalert.org/pub_releases/2007-11/cfgd-crc111207.php

Dunlap, Riley E. and McCright, Araon M.(2008) 'A Widening Gap: Republican and Democratic Views on Climate Change', Environment: Science and Policy for Sustainable Development, 50: 5, 26-35 http://dx.doi.org/10.3200/ENVT.50.5.26-35

Georgia's Electric Membership Corporations. N.p.: Georgia's Electric Membership Corporations, n.d. *Opc.com*. Oglethorpe Power, 2007. Web. 2015. http://www.opc.com/oracle_cons/groups/public/@opc-web/documents/webcontent/ct_000345.pdf

Georgia Power Company. (2012). Annual Report. Retrieved from http://www.georgiapower.com/docs/about-us/2012-Annual-Report.pdf

"Overview." *Georgia Power Company Home*. A Southern Company, n.d. Web. 26 Feb. 2015. http://www.georgiapower.com/

Kasper, Matt. "ALEC's Anti-Renewable Energy Agenda - July 2014."*Energy and Policy Institute* (2014): n. pag. *Energy and Policy Institute*. Web. Jan. 2015. http://www.energyandpolicy.org/alec_s_attack_on_clean_energy

Lyon, Thomas P., and Haitao Yin. "Why Do States Adopt Renewable Portfolio Standards?: An Empirical Investigation." *The Energy Journal*31.3 (2010): 131-56. *IAEE*. Web. 2 Feb. 2015

Rabe, Barry. "Race to the Top: The Expanding Role of U.S State Renewable Portfolio Standards." Sustainable Development Law & Policy, Spring 2007, 10-16, 72.

Renewable Portfolio Standards." *ALEC*. American Legislative Exchange Council, Oct. 2013. Web. Jan. 2015. <Kasper, Matt. "ALEC's Anti-Renewable Energy Agenda - July 2014." Energy and Policy Institute (2014): n. pag. Energy and Policy Institute. Web. Jan. 2015>

Ryerson, T. B. "Observations of Ozone Formation in Power Plant Plumes and Implications for Ozone Control Strategies." *Science* 292.5517 (2001): 719-23. *MITei*. MIT Energy Initiative. Web. Jan. 2015.

Shrimali, Gireesh and Jenner, Steffen and Groba, Felix and Chan, Gabriel and Indvik, Joe, Have State Renewable Portfolio Standards Really Worked? Synthesizing Past Policy Assessments to Build an Integrated Econometric Analysis of RPS effectiveness in the U.S. (October 25, 2012). USAEE Working Paper No. 12-099; DIW Berlin Discussion Paper No. 1258.

Southern Company. N.p.: Southern, n.d. *Plant Vogtle Units 3 and 4*. Southern Company, 2012. Web. http://www.southerncompany.com/what-doing/energy-innovation/nuclear-energy/pdfs/vogtle-nuclear-brochure.pdf

"Top Headlines." *Smart Energy. Smart Grid. Smart Choices. New Nuclear, Biomass and Solar Plants, Intelligent Transmission Equipment and Efficiency Programs.* Southern Company, n.d. Web. 26 Feb. 2015. http://www.southerncompany.com/

United States of America. Department of Commerce. US Census Bureau. N.p.: n.p., n.d. *US Census Bureau*. Web. Dec. 2014

United States of America. Georgia Government Transparency and Campaign Finance Commission. Campaign Finance Commission. *Campaign Reports- By Contribution*. CFC, n.d. Web. Dec. 2014.

United States of America. US Energy Information Administration. Georgia Energy Data. N.p.: n.p., n.d. *Southface*. Web. Feb. 2015

United States of America. US Energy Information Administration. Independent Statistics and Analysis. *Georgia/ State Profile and Energy Estimates*. US EIA, Oct. 2014. Web. Oct. 2014 http://www.eia.gov/state/seds/data.cfm?incfile=/state/seds/sep_fuel/html/fuel_te.html&sid=US&sid=GA

United States of America. US Energy Information Administration. Independent Statistics and Analysis. N.p.: n.p., n.d. *US Department of Energy*. Web. Oct. 2014. http://www.eia.gov/todayinenergy/detail.cfm?id=4850

United States of America. The Environmental Protection Agency. Department of Energy. *Clean Energy*. N.p.: n.p., n.d. *US EPA*. Web. Oct. 2014

Vogel, K.P., J. Brieda, D. Walters, D. Ruxton "Switchgrass biomass production in the Midwest USA: Harvest and Nitrogen Management. Agronomy Journal 94: 413-420 (2002)